System for controlling recirculated exhaust gas temperature in an internal combustion engine

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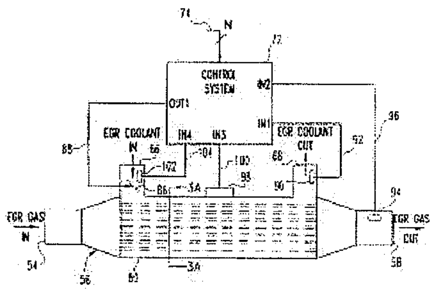
A system for controlling the temperature of recirculated exhaust gas supplied to an internal combustion engine is provided. In one embodiment, the system includes a heat exchanger having the recirculated exhaust gas flowing therethrough and further having coolant fluid flowing therethrough. A control valve is disposed within the flow path of the coolant fluid, and the valve position is modulated to vary the rate of coolant fluid flow through the heat exchanger, thereby controlling the temperature of the recirculated exhaust gas supplied by the heat exchanger. In another embodiment, the heat exchanger defines a number of exhaust gas flow passages therethrough and a number of gas flow control valves are disposed between the exhaust gas inlet of the heat exchanger and the number of exhaust gas flow passages.; The exhaust gas flow control valves are selectively actuated to disable exhaust gas flow through any number of subsets of the exhaust gas flow passages, thereby controlling the temperature of recirculated exhaust gas supplied by the heat exchanger.



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(54) **System for controlling recirculated exhaust gas temperature in an internal combustion engine**

System zur Steuerung der Temperatur des rückgeführten Abgas in einer Brennkraftmaschine

Système pour contrôler la température de gaz d'échappement recirculé dans un moteur à combustion interne

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Description

Field of the Invention:

[0001] The present invention relates generally to exhaust gas recirculation (EGR) systems of internal combustion engines, and more specifically to techniques for controlling recirculated gas temperature.

BACKGROUND OF THE INVENTION

[0002] It is generally recognized that the production of noxious oxides of nitrogen (NO_x) which pollute the atmosphere are undesirable. Steps are therefore typically taken to eliminate, or at least minimize, the formation of NO_x constituents in the exhaust gas products of an internal combustion engine.

[0003] The presence of NO_x in the exhaust gas of internal combustion engines is generally understood to depend, in large part, on the temperature of combustion within the combustion chamber of the engine. In connection with controlling the emissions of such unwanted exhaust gas constituents from internal combustion engines, it is widely known to recirculate a portion of the exhaust gas back to the air intake portion of the engine (so-called exhaust gas recirculation or EGR). Since the recirculated exhaust gas effectively reduces the oxygen concentration of the combustion air, the flame temperature at combustion is correspondingly reduced, and since NO_X production rate is exponentially related to flame temperature, such exhaust gas recirculation (EGR) has the effect of reducing the emission of NO_X.

[0004] It is further known to cool the recirculated exhaust gas prior to introduction of the gas at the engine air intake port. An EGR cooler is therefore typically arranged within the exhaust gas recirculation system to cool the stream of recirculated exhaust gas, see JP-A-55131556 for example. The temperature of the exhaust gas exiting from the cooler is critical both to the NO_x control process and to the integrity of the cooler and the downstream components, such as EGR conduits, EGR flow control valves and the engine itself. However, due to the wide range of EGR gas conditions at the cooler, and under certain operating conditions of the engine, it is desirable to have active control of the EGR gas temperature at the outlet of the EGR cooler. For example, while a typical EGR cooler may satisfactorily cool EGR gas under full-load engine conditions, under light-loaded conditions of the engine, that is, where EGR flow rates are relatively low, the EGR gas may be overcooled. This results in the accumulation of carbon and acid condensates on the mechanical components downstream of the EGR cooler outlet, thereby compromising the integrity of the EGR cooler and the downstream mechanical components, including the engine.

[0005] FIG. 1 is a diagrammatical illustration of a known EGR system 10 including known components for actively controlling the temperature of the recirculated exhaust gas. Referring to FIG. 1, an internal combustion engine 12 includes an air intake manifold 14 attached to the engine 12 and coupled to the various combustion chambers of the engine, which receives intake ambient air via conduit 16. An exhaust gas manifold 18 is attached to the engine 12 and coupled to the exhaust gas ports of the various combustion chambers of the engine, and supplies exhaust gas to the ambient via exhaust gas conduit 20. The engine 12 typically includes a fan 22 which is driven by the rotary motion of the engine, and which is typically used to cool engine coolant fluid flowing through a radiator (not shown) positioned proximate to the fan 22.

[0006] A first conduit 24 is connected at one end to the exhaust gas manifold 18, and at its opposite end to EGR cooler 26. An EGR flow control valve 28 is connected at one end thereof to EGR cooler 26 via conduit 30, and at an opposite end thereof to intake manifold 14 via conduit 32.

[0007] In accordance with one known technique for actively controlling the temperature of the recirculated exhaust gas provided to EGR flow control valve 28, and example of which is set forth in U.S. Patent No. 4,147,141 to Nagano, a second exhaust gas flow control valve 40 is interposed between sections of conduit 24, and provides a bypass flow path therefrom to conduit 30 via conduit 42 (both shown in phantom). A control circuit 34 includes an input/output (I/O) port connected to EGR flow control valve 28 via signal path 38, and an output OUT1 connected to exhaust gas flow control valve 40 via signal path 44.

[0008] In operation, the EGR flow control valve 28 may include a temperature sensor therein which provides a temperature signal to control circuit 34, via signal path 38, corresponding to the temperature of recirculated exhaust gas provided to valve 28. In response to the temperature signal, control circuit 34 provides a corresponding control signal to exhaust gas control valve 40, which is operable to divert any desired amount of exhaust gas directly to EGR flow control valve 28 via conduit 40, thereby bypassing EGR cooler 26. In this manner, control system 34 is operable to control the temperature of recirculated exhaust gas supplied to EGR flow control valve 28 by controlling the amount of recirculated exhaust gas that flows through EGR cooler 26, and the amount of recirculated exhaust gas that flows through bypass conduit 42.

[0009] In accordance with another known technique for actively controlling the temperature of the recirculated exhaust gas provided to EGR flow control valve 28, an example of which is set forth in U.S. Patent No. 4,323,045 to Yamashita, control circuit 34 includes an output OUT2 connected to a fan 46 via signal path 48 (shown in phantom). In the Yamashita system, exhaust gas flow control valve 40 and bypass conduit 42 are omitted so that conduit 24 connects exhaust gas manifold 18 directly to EGR cooler 26. In operation, control circuit 34 monitors intake manifold air pressure via sig-

nal path 38, which may be connected to a pressure sensor mechanism located within EGR flow control valve 28 or a separate pressure sensing mechanism coupled to the air intake manifold, and actuates the fan 46, which is located proximate to EGR cooler 26, accordingly. For example, when the engine load is low, and air intake vacuum is high, control system 34 does not actuate fan 26, and EGR cooler 26 is therefore not externally cooled. However, as engine load increases, and intake manifold vacuum correspondingly decreases, control system 34 energizes fan 46, which externally cools EGR cooler 26 and thereby enhances the cooling effect thereof.

[0010] While each of the foregoing known techniques for actively controlling the temperature of recirculated exhaust gas may be somewhat effective, both suffer from inherent drawbacks. For example, while the Nagano arrangement provides for a high degree of control over the temperature of recirculated exhaust gas provided to EGR flow control valve 28, it should be understood that, under certain engine operating conditions, the recirculated exhaust gas provided to EGR flow control valve 28 may be a mixture of un-cooled exhaust gas flowing through bypass conduit 42 and over-cooled exhaust gas flowing through EGR cooler 26 and the portion of conduit 30 upstream of bypass conduit 42. Under such operating conditions, EGR cooler 26 and the portion of conduit 30 upstream of bypass conduit 42 are thus subject to the deleterious effects of over-cooled exhaust gas as described above. Moreover, available space in the engine compartment of the vehicle may be limited, and there simply may not be room to include the extra bypass conduit 42 and associated exhaust gas flow control valve 40. While fan 46, on the other hand, provides for enhanced cooling of the EGR cooler 26 itself, and may thereby obviate the need for bypass conduit 42, the fan arrangement provides for only a relatively low degree of recirculated exhaust gas temperature control. Specifically, fan 46 permits only a two-level cooling effect, i.e. either fan "off" or fan "on".

[0011] What is therefore needed is a system for providing active control over recirculated exhaust gas temperature that permits a high-degree of temperature control while minimizing exhaust gas over-cooling conditions which lead to degradation in the integrity of the EGR cooler and the downstream mechanical components, including the engine. Preferably, such an EGR temperature control system should consume minimal space in the engine compartment, and should therefore preferably be incorporated within the EGR cooler design itself.

SUMMARY OF THE INVENTION

[0012] The foregoing shortcomings of known prior art systems are addressed by the present invention.

[0013] According to one aspect of the present invention, there is provided apparatus for controlling the temperature of recirculated exhaust gas in an internal combustion engine as claimed in claim 1. Preferred features are claimed by the sub-claims 2-19.

[0014] One embodiment of the present invention includes an apparatus for controlling the temperature of recirculated exhaust gas in an internal combustion engine, the apparatus having a first conduit coupled at one end to an exhaust gas port of the engine, a second conduit coupled at one end to an air inlet port of the engine, and a heat exchanger including a gas inlet port connected to an opposite end of the first conduit and receiving exhaust gas therefrom, and a gas outlet port connected to an opposite end of the second conduit and supplying recirculated exhaust gas thereto. The heat exchanger further includes means for varying a heat exchange capability of the heat exchanger, and the apparatus further includes means for controlling the means for varying a heat exchange capability of the heat exchanger, to thereby control the temperature of the recirculated exhaust gas.

[0015] Preferably the apparatus further includes a source of coolant fluid, the heat exchanger includes a coolant inlet port connected to the source of coolant fluid and a coolant outlet port, and defines a coolant flow path therethrough from the source of coolant fluid to the coolant outlet port.

[0016] Further in accordance with the present invention, the heat exchanger defines a number of exhaust gas flow paths therethrough from the gas inlet port to the gas outlet port, and wherein the means for varying a heat exchange capability of the heat exchanger includes means for selectively disabling exhaust gas flow through certain ones of the number of the number of exhaust gas flow paths. One means for controlling the means for varying heat exchange capability of the heat exchanger includes means for determining recirculated exhaust gas temperature and selectively disabling exhaust gas flow through certain ones of the number of exhaust gas flow paths in accordance therewith to thereby control the temperature of the recirculated exhaust gas. Alternatively, the means for controlling the means for varying heat exchange capability of the heat exchanger includes means for determining a flow rate of the recirculated exhaust gas and selectively disabling exhaust gas flow through certain ones of the number of exhaust gas flow paths in accordance therewith to thereby control the temperature of the recirculated exhaust gas.

[0017] In accordance with a feature of the present invention, the heat exchanger defines a gas bypass channel therethrough from the gas inlet port to the gas outlet port, wherein the gas bypass channel bypasses all gas flow paths therethrough such that the temperature of exhaust gas flowing through the heat exchanger is only minimally affected by the heat exchanger.

[0018] The present invention provides a system for actively controlling the temperature of recirculated exhaust gas provided to an internal combustion engine.

The system has an EGR cooler defining a number EGR gas flow paths therethrough, wherein the EGR cooler includes means for selectively disabling EGR gas through certain ones of the number of EGR gas flow paths to thereby control the temperature of the recirculated exhaust gas.

[0019] These and other objects of the present invention will become more apparent from the following description of the preferred embodiment.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020]

FIG. 1 is a diagrammatic illustration of known techniques for actively controlling the temperature of recirculated exhaust gas provided to an air intake port of an internal combustion engine;
FIG. 2 is a diagrammatic illustration of one embodiment of a system for controlling the temperature of recirculated exhaust gas provided to an air intake port of the engine, in accordance with one aspect of the present invention;
FIG. 3 is a diagrammatic illustration of one embodiment of the EGR cooler and associated control system components of FIG. 2, showing details thereof;
FIG. 3A is a cross-sectional view of the EGR cooler of FIG.3, viewed along section lines 6A-6A;
FIG. 4 is a diagrammatic illustration of an alternate embodiment of the EGR cooler and the associated control system components of FIG.2, showing details thereof;
FIG.5A is a cross-sectional view showing one embodiment of the internal structure of the EGR cooler of FIG. 4, viewed along section lines 8-8;
FIG.5B is a cross-sectional view showing the internal structure of another embodiment of the EGR cooler of FIG. 4, viewed along section lines 8-8;
FIG. 5C is a cross-sectional view showing the internal structure of yet another embodiment of the EGR cooler of FIG. 4, viewed along section lines 8-8;
FIG. 6A is a cross-sectional view showing one embodiment of the valve engaging wall of the EGR cooler of FIG. 4, viewed along section lines 9-9; and
FIG. 6B is a cross-sectional view showing an alternate embodiment of the valve engaging wall of the EGR cooler of FIG. 4, viewed along section lines 9-9.

DESCRIPTION OF THE PREFERRED EMBODIMENT

[0021] For the purposes of promoting an understanding of the principles of the invention, reference will now be made to embodiments illustrated in the drawings and specific language will be used to describe the same. It will nevertheless be understood that no limitation of the scope of the protection claimed by the claims is thereby intended, such alterations and further modifications in the illustrated devices, and such further applications of the principles of the protection claimed by the claims as illustrated therein being contemplated as would normally occur to one skilled in the art to which the invention relates.

[0022] The present invention is directed to a technique for controlling recirculated exhaust gas temperature in an exhaust gas recirculation system of an internal combustion engine. In so doing, the present invention exercises active control over the recirculated exhaust gas temperature by controlling the heat exchange capability of a heat exchanger, or EGR cooler, in an exhaust gas recirculation system. As used herein, the term "heat exchange capability" of such a heat exchanger is defined as the ability of the heat exchanger itself to transfer heat therefrom to ambient.

[0023] The EGR gas temperature exiting from an EGR heat exchanger depends of many factors including EGR mass flow rate and effective Reynolds number (heat exchanger effectiveness), heat exchanger cooler flow rate (in fluid cooled heat exchangers), the state of EGR gas at the heat exchanger inlet (pressure, temperature and composition vary with such factors as engine speed and load, air-fuel ratio, fuel composition and the like), coolant temperature at the heat exchanger cooler inlet (which varies as a function of engine speed and load, ambient temperature and other factors), the extent of fouling or exhaust deposits in the heat exchanger and the design of the heat exchanger itself (including cooling mechanism such as air or liquid, flow-type such as parallel-flow or counter-flow, active heat exchanging surface, and other factors).

[0024] In carrying out the present invention, the heat exchange capability of an EGR heat exchanger is controlled by varying the heat exchanger effectiveness which has the ultimate effect of controlling the temperature of EGR gas exiting the heat exchanger.

[0025] Referring now to FIG. 2, one embodiment of a system 125 for actively controlling the temperature of recirculated exhaust gas provided to an air intake port of an engine, in accordance with one aspect of the present invention, is shown. System 125 includes an internal combustion engine 12 having an air intake manifold 14 attached thereto and coupled to the various combustion chambers of the engine (not shown), which received intake ambient air via conduit 16. An exhaust manifold 18 is attached to the engine 12 and coupled to the exhaust ports of the various combustion chambers of the engine (not shown), and supplies exhaust gas to the ambient via exhaust gas conduit 20. The engine 12 includes a fan 22 which is driven by the rotary motion of the engine, and which may be used to cool a fluid source 62 as will be described hereinafter. In one preferred embodiment, internal combustion engine 12 is a diesel engine, although the present invention contemplates utilizing the techniques described herein with any internal combustion engine.

[0026] A first conduit 51 is connected at one end to

the exhaust gas manifold 18, and at its opposite end to a known EGR flow control valve 28, which is shown in phantom in FIG. 2. A second conduit 52 is connected at one end to EGR flow control valve 28, and at its opposite end to an input port 122 of a heat exchanger, or EGR cooler 120. An output port 124 of EGR cooler 120 is connected to air intake manifold 14 via conduit 60. Alternatively, as is also shown in phantom in FIG. 2, EGR flow control valve 28 may be interposed between EGR cooler 120 and air intake manifold 14, and connected to conduits 32 and 60 as shown. It is to be understood that provisions for EGR coolant fluid flow through EGR cooler 120 are not strictly required in system 125 of the present invention, although such coolant flow is preferred

[0027] If the source of heat exchanger coolant fluid 62 is included in the EGR cooler 120, it would be connected via conduit 64 to a coolant inlet port 66 of EGR cooler 120, and a coolant outlet port 68 of EGR cooler 120 would be connected back to coolant fluid source 62 via conduit 70. Preferably, coolant fluid source 62 is a known engine radiator positioned proximate to cooling fan 22, and contains a known engine coolant fluid flowing therethrough, although the present invention contemplates that coolant fluid source 62 may be any source of coolant fluid. For example, the present invention contemplates utilizing a coolant fluid source having a coolant fluid therein with a boiling point that is higher than conventional water-glycol engine coolant fluid. In such a case, coolant fluid source 62 and conduits 64 and 70 would require at least a fluid pump, condenser and fluid pressure control device (not shown) as is known in the art. Such a coolant fluid could be circulated through EGR cooler 120 at a temperature which would be a function of the coolant fluid pressure, thereby providing for highly accurate control of EGR gas temperature, and permitting resultantly higher EGR gas temperatures than with conventional water-glycol mixtures.

[0028] An electronic control system 126 is operable to receive a number N of inputs indicative of various vehicle, system, or machine operating parameters at input IN_{OP} via signal path 128. An input/output (I/O) is connected to EGR flow control valve 28 via signal path 38, whereby control system 126 is operable to control the flow rate of recirculated exhaust gas therethrough in accordance with known techniques. Input IN_{EC} of control system 126 is connected to an output OUT of EGR cooler 120 via signal path 130, which may include any number K of signal lines. An output OUT_{EC} of control system 126 provides a number J of control signal paths to a corresponding number of control signal inputs at input IN of EGR cooler 120 via signal path 132 as is known in the art.

[0029] In one preferred embodiment, system 125 is incorporated into an automotive application having a known electronic control system. Preferably, control system 126 is microprocessor-based and may comprise at least a portion of a known engine, vehicle or system computer. Such an electronic control system typically includes a number of known sensors for determining such engine operating parameters as engine load, engine speed, mass air flow, intake manifold air pressure, percent throttle and the like. Although not shown specifically in the drawings, outputs from such sensors, or outputs from such an electronic control system, may be received as one or more of the N inputs 128 at input IN_{OP} of control system 126 (FIG. 2). Based on this information, EGR flow rate will be generally known, or readily computable from existing signals, in such systems so that an optimum, or desired, EGR gas temperature can be determined as a function thereof, or as a function of any number or combination of such engine operating parameters.

[0030] As shown in FIG.2, EGR flow control valve 28 may additionally or alternatively include a pressure sensing mechanism 29 which is operable to sense the pressure of EGR gas flowing through valve 28 and provide a signal corresponding thereto to control system 126. Pressure sensing mechanism 29 may be actually positioned anywhere within the EGR gas flow path, the importance being that mechanism 29 is operable to sense the pressure of EGR gas provided by EGR cooler 120 to intake manifold 14 of engine 12. Control system 126 is operable to convert such a pressure signal to a flow rate signal in accordance with known techniques.

[0031] Referring now to FIG.3, one embodiment of heat exchanger, or EGR cooler, 120 and associated control system components are shown. The EGR cooler 120 shown in FIGS. 3 and 3A is a so-called parallel-flow EGR cooler. However it is to be understood that EGR coolers having other flow types may also be used with the present invention, including, for example, counter-flow EGR coolers. EGR cooler 120 includes the EGR gas inlet port 122 at one end thereof and the EGR gas outlet port 124 at an opposite end thereof. EGR cooler 120 includes a housing 140 defining EGR gas inlet port 122 and EGR gas outlet port 124, and in a preferred embodiment of EGR cooler 120, further defines EGR coolant inlet port 66 and EGR coolant outlet port 68.

[0032] Referring to FIG. 3A, exhaust gas entering EGR gas inlet port 122 flows towards EGR gas outlet port 124 via a number of exhaust gas flow passages 142, which are preferably constructed of hollow tubes. Areas 144 surrounding EGR gas flow passages 142 define a coolant flow path for the EGR coolant supplied by coolant fluid source 62. The EGR gas flow path structure of FIG. 3A is a known design for maximizing the surface area of EGR cooler 120 that may be cooled by EGR coolant fluid from cooler fluid source 62, wherein the surface area of EGR cooler 120 that is exposed to incoming exhaust gas is defined by the number and surface area of exhaust gas flow passages 142.

[0033] Control system 126 is, in the embodiment shown in FIG. 3, operable to determine recirculated exhaust gas temperature. To this end, EGR cooler 120 may include one or more temperature sensors operable

to sense the temperature of a corresponding component of EGR cooler 120. For example, one temperature sensor 90 may be disposed within EGR cooler outlet port 68, which is connected to input IN1 of control system 126 via signal path 92. However, the present invention contemplates positioning temperature sensor 90 anywhere within EGR coolant outlet port 68 or conduit 70 (FIG. 2), the importance being that temperature sensor 90 is operable to sense the temperature of EGR coolant fluid exiting EGR cooler 120. A temperature sensor 94 may further be disposed within EGR gas outlet port 124 of EGR cooler 120, which is connected to input IN2 of control system 126 via signal path 96. As with temperature sensor 90, it is to be understood that temperature sensor 94 may be located anywhere within EGR gas outlet port 124, conduit 60 (FIG. 2), flow control valve 28 or conduit 32, the importance being in that temperature sensor 94 is operable to sense the temperature of EGR gas provided by EGR cooler 120 to the air intake manifold 14 of engine 12.

[0034] A temperature sensor 98 may further be attached to the housing 140 of EGR cooler 120, which is connected to input IN3 of control system 126 via signal path 100. Temperature sensor 98 may be attached anywhere on EGR cooler 120 in contact with housing 140, or in close proximity thereto, the importance being that temperature sensor 98 is operable to sense a temperature of the housing 140 of EGR cooler 120. A temperature sensor 102 may further be disposed within EGR coolant inlet port 66, which is connected to input IN4 of control system 126 via signal path 104. Temperature sensor 102 may be positioned anywhere within EGR coolant inlet port 66 or conduit 64 (FIG. 2), the importance being that temperature sensor 102 is operable to sense the temperature of EGR coolant fluid flowing from coolant fluid source 62 into EGR cooler 120.

[0035] The EGR gas flow passages 142 of EGR cooler 120 are partitioned into two subsets 146 and 148 as shown in FIG. 3A. It is to be understood however, that the dashed dividing line 145 is included only to illustrate the partitioning of gas flow passages 142 into subsets 146 and 148, and should not be interpreted as defining a structural partition wall extending through cooler 120. A partitioning mechanism separates the number of EGR gas flow passages 142 into the two subsets, and the partitioning mechanism 150 is preferably a flap valve or similar such structure coupled to an electronic actuator 152 via mechanical linkage L. Actuator 152 is connected to an output OUT1 of control system 126 via signal path 154. Flap valve 150 is actuatable by control system 126 to one of two positions. In a valve closed position, as illustrated in FIG.3, flap valve 150 disables EGR gas entering EGR gas inlet 122 from flowing through gas flow passages 142 of subset 146. Conversely, in the valve opened position, EGR gas flowing into EGR gas inlet 122 is directed through all EGR gas passages 142 of subsets 146 and 148. Thus, control system 126 is operable to actuate flap valve 150 to either enable EGR gas flowing into EGR inlet 122 to flow through all EGR gas flow passages 142, or to disable EGR gas from flowing through EGR gas flow passages 142 of subset 146 and thereby enable flow only through those EGR gas passages 142 of subset 148. Preferably, subsets 146 and 148 include an equal number of EGR gas flow passages 142, as illustrated in FIG. 3A, although the present invention contemplates that EGR gas flow passages 142 may be partitioned into subsets 146 and 148 having unequal numbers of EGR gas flow passages 142 therein.

[0036] In the operation of the embodiment of system 125 illustrated in FIGS. 3 and 3A, the heat exchange capability of EGR cooler 120 is varied by changing the surface area of EGR cooler 120 exposed to incoming EGR gas by controlling the position of flap valve 150. As discussed hereinabove, the surface area of EGR cooler 120 that is exposed to incoming EGR gas is defined by the number and cross-sectional area of EGR gas flow passages 142.

[0037] The present invention contemplates actuating flap valve 150 via control system 126 in accordance with either temperature signals received from one or more temperature sensors 90, 94, 98 and 102, in a manner discussed hereinabove with respect to FIG. 3, or in accordance with either known engine operating parameters and/or an EGR flow rate signal provided by EGR flow rate control valve 28 as discussed hereinabove.

[0038] In any case, control system 126 is responsive to the temperature, EGR gas flow rate and/or other engine operating parameter signals provided thereto to control the position of flap valve 150. In accordance with any of the signals discussed hereinabove, flap valve 150 may be opened to allow passage of EGR gas through both subsets 146 and 148 of EGR flow passages 142, thereby maximizing the cooling effect of EGR cooler 120, or flap valve 150 may be closed so that incoming EGR gas is directed only through subset 148 of EGR flow passages 142, thereby decreasing the cooling effect of EGR cooler 120.

[0039] Referring now to FIG. 4, an alternate embodiment of EGR cooler 120 and associated control system components of system 125 of FIG. 2 is shown. The embodiment of FIG. 4 is identical in many respects to the embodiment of FIG. 3 and like reference numbers are therefore used to identify like components. Previously discussed components will not be discussed further for brevity.

[0040] The embodiment of EGR cooler 120 and associated control system components of FIG. 4 differ from that shown and described with respect to FIG. 3 in two areas, namely in the structure of EGR gas inlet control valves and in the partitioning of the EGR gas flow passages. In the embodiment of FIG. 4, any number of EGR gas flow control valves may be used to partition the EGR gas flow passages of EGR cooler 120 into a corresponding number of subsets thereof.

[0041] Referring to FIG. 4, EGR gas inlet port 122

leads to a throat portion 174 having a wall 176 therein which defines three gas flow passages therethrough. Three valves 178, 180 and 182 are connected to corresponding electronic actuators 184, 186 and 188 respectively. Actuator 184 is connected to output OUT3 of control system 126 via signal path 194, actuator 186 is connected to output OUT2 of control system 126 via signal path 192 and actuator 188 is connected to output OUT1 of control system 126 via signal path 190.

[0042] Each of the valves 178-182 may be individually pulled away from wall 176 under the control of control system 126, as illustrated by valve 182 in FIG. 4, to permit incoming EGR gas to flow through a corresponding gas flow passage defined in wall 176 and into a subset of EGR gas flow passages 162 defined within housing 160 of EGR cooler 120. Additionally, each of the valves 178-182 may be individually advanced toward wall 176 under the control of control system 126, into sealing engagement with a corresponding EGR gas flow passageway defined therein, as illustrated in FIG. 4 by valves 178 and 180. In the advanced position, each valve is operable to disable EGR gas from flowing through a corresponding partitioned subset of EGR gas flow passages 162.

[0043] The embodiment illustrated in FIG. 4 is nearly identical to the embodiment shown in FIG. 3 in that control system 126 is operable to control the surface area of EGR cooler 120 that is exposed to EGR gas in accordance with temperature, EGR flow rate and/or engine operating condition signals as described hereinabove. In the embodiment of FIG. 4, control system 126 does so by selectively withdrawing and advancing any of valves 178-182 to thereby effectively control the heat exchange capability of EGR cooler 120.

[0044] While the embodiment illustrated in FIG. 4 is shown as having three flow control valves 178-182, it is to be understood that the present invention contemplates partitioning the number of EGR gas flow passages 162 into any number of subsets, thereby requiring any corresponding number of flow control valves. In FIG. 4, three such flow control valves 178-182 are shown and the number of EGR gas flow passages 162 are therefore partitioned into three separate subsets. Referring to FIG. 5A , one preferred partitioning scheme partitions the number of EGR gas flow passages 162 into three approximately equal subsets 166A, 166B and 166C thereof. Within each subset, areas 164 about EGR gas flow passages 162 define an EGR coolant flow path, if such an EGR fluid source 62 is provided. Referring to FIG. 5B , an alternate partitioning scheme partitions the number of EGR gas flow passages 162 into three subsets 168A, 168B and 168C having unequal numbers of EGR gas flow passages therein.

[0045] Referring now to FIG. 5C , the present invention contemplates substituting at least one subset of EGR gas flow passages 162 with an EGR gas bypass channel 172 defined by walled portion 172a, leaving the number of EGR gas flow passages 162 to be partitioned into two equal or unequal subsets 170A and 170B. In the embodiment shown in FIG. 5C , bypass channel 172 defines a very low effectiveness EGR gas cooling path through the cooler 120, with a similarly low pressure drop therethrough, so that the temperature and pressure of EGR gas flowing therethrough is only minimally affected. In accordance with another aspect of the present invention, control system 126 is operable, under light engine load conditions, to disable EGR gas from flowing through subsets 170A and 170B and direct all of the EGR gas through bypass channel 172, thereby effectively bypassing the cooling effect of EGR cooler 120 and thereby avoiding fouling and condensation of cooler 120 as well as the downstream mechanical components. Under heavier engine load conditions, control system 126 is operable to selectively enable EGR gas flow through subsets 170A and/or 170B. As with the previous embodiments discussed hereinabove, control system 126 is operable to control EGR gas flow through any of the partitioning arrangements shown in FIGS. 5A-5C in response to temperature signals from any of temperature sensors 90-102, or in response to either engine operating parameters and/or sensed EGR gas flow rate conditions as discussed hereinabove. As with the partitioning embodiment shown in FIG. 3A , it is to be understood that the dashed-line partition segments in FIGS. 5A-5C are provided for, illustration only, and do not represent any wall structure within cooler 120.

[0046] With any of the partitioning structures of FIGS. 5A-5C, the present invention contemplates that the EGR gas flow control valve 28 of FIG. 2 may be omitted, so that control system 126 may simultaneously control the flow rate and temperature of EGR gas provided to intake manifold 14 of engine 12 through control of valves 178-182. Such an arrangement would not only provide for a high level of active control over the temperature of EGR gas provided at outlet 124, with all the benefits thereof described herein, but would further obviate the need for the expensive and space consuming EGR gas flow control valve 28.

[0047] Referring to FIG. 6A , one embodiment of valve engaging wall 176 of cooler 120 of FIG. 4 is shown. In the embodiment of FIG. 6A , wall 176 includes three identically sized bores 200, 202 and 204 therethrough, each of which are adapted to sealingly engage a corresponding one of valves 178, 180 and 182. In this embodiment, each of the bores 200-204 are configured to provide for an-approximately equal gas flow rate therethrough. Referring to FIG.6B , an alternate embodiment of valve engaging wall 176 of cooler 120 of FIG. 4 is shown. In the embodiment of FIG. 6B , wall 176 includes three bores 206, 208 and 210 therethrough, wherein the widths of the bores as well as the width of the corresponding valves 178, 180 and 182 are graduated to provide for proportional flow of gas therethrough. Thus, the control system 126 may selectively actuate valves 178-182 as described hereinabove to provide for "trimming" of the EGR gas flow rate in response to degrada-

tion of cooler 120 or other sources of variability in EGR gas flow rate.

[0048] While the invention has been illustrated and described in detail in the drawings and foregoing description, the same is to be considered as illustrative and not restrictive in character, it being understood that only the preferred embodiments have been shown and described and that all changes and modifications that come within the scope of the protection claimed by the claims are desired to be protected. For example, while the present invention has been described herein to some extent as being directed a motor vehicle application, and to one having a diesel engine specifically, it is to be understood that the present invention contemplates that the concepts described herein may be incorporated into any machine which includes an internal combustion engine. Further, it is to be understood that the present invention contemplates that any of the techniques separately described hereinabove may be combined to form a combination EGR gas cooler and EGR gas flow rate controller so that an EGR flow rate control valve 28 may be omitted as unnecessary. For example, the partitioned cooler 120 of FIG. 4 may be used with either valve wall 176 embodiment to provide for controlled EGR gas temperature and flow rate. Similarly, the partitioned cooler 120 of FIG. 4 may be used with either valve wall 176 embodiment in conjunction with the coolant flow techniques described herein to provide for a high level of control over both EGR gas flow rate and EGR gas temperature. Other combinations of the various structures and techniques described herein will become apparent to those skilled in the art. It should further be noted that the term "engine operating parameter" as used herein should be understood to mean any of the EGR temperature sensor signals described herein, any of the EGR gas flow rate signals described herein and/or any of the engine operating parameters typically available in an electronically controlled engine and/or machine such as, for example, engine load, air intake manifold pressure, mass air flow rate, throttle percentage, engine RPM, engine fueling rate, and *the* like.

Claims

1. Apparatus (125) for controlling the temperature of recirculated exhaust gas in an internal combustion engine (12), comprising:

   a first conduit (51 and 52) coupled at one end to an exhaust gas port (18) of the engine (12);
   a second conduit (32 and 60) coupled at one end to an air inlet port (14) of the engine (12);
   a heat exchanger (120) including a gas inlet port (122) connected to an opposite end of said first conduit (51 and 52) and receiving exhaust gas therefrom, a gas outlet port (124) connected to an opposite end of said second conduit (32 and 60) and supplying recirculated exhaust gas thereto, said heat exchanger (120) defining an exhaust gas flow path (142, 162) therethrough from said gas inlet port (122) to said gas outlet port (124);

   characterised by

   said exhaust gas flow path being one of a number of such exhaust gas flow paths (142, 162) through said heat exchanger (120) from said gas inlet port (122) to said gas outlet port (124);

   means (145, 150, 178, 180, 182) for selectively disabling exhaust gas flow through certain ones of said number of exhaust gas flow paths (142, 162); and

   means (152, 184, 186, 188) for controlling said means (145, 150, 178, 180, 182) for selectively disabling exhaust gas flow through certain ones of said number of exhaust gas flow paths (142, 162) to thereby control the temperature of said recirculated exhaust gas.

2. Apparatus (125) according to claim 1, wherein said means (145, 150, 178, 180, 182) for selectively disabling exhaust gas flow through certain ones of said number of exhaust gas flow paths (142, 162) includes a first exhaust gas control valve (150, 178, 180, 182) responsive to a first control signal to disable gas glow through a first subset (146, 166A, 166B, 166C, 168A, 168B, 168C, 170A, 170B) of said number of exhaust gas flow paths (142, 162) to thereby vary said heat exchange capability of said heat exchanger (120).

3. Apparatus (125) according to claim 2, wherein said means (178, 180, 182) for selectively disabling exhaust gas flow through certain ones of said number of exhaust gas flow paths (162) includes a second exhaust gas control valve (178,180, 182) responsive to a second control signal to disable gas flow through a second subset (166A, 166B, 166C, 168A, 168B, 168C, 170A, 170B) of said number of exhaust gas flow paths (162) to thereby vary said heat exchange capability of said heat exchanger (120).

4. Apparatus (125) according to claim 3, wherein said means (178, 180, 182) for selectively disabling exhaust gas flow through certain ones of said number of exhaust gas flow paths (162) includes a third exhaust gas control valve (178, 180, 182) responsive to a third control signal to disable gas flow through a third subset (166A, 166B, 166C, 168A, 168B, 168C, 170A, 170B) of said number of exhaust gas flow paths (162) to thereby vary said heat exchange capability of said heat exchange (120).

5. Apparatus (125) according to claim 3, wherein said heat exchanger (120) defines a gas bypass channel

(172) therethrough from said gas inlet port (122) to said gas outlet port (124), said gas bypass channel (172) providing for exhaust gas flow therethrough with a minimal effect on the temperature of the exhaust gas;

and wherein said means (178, 180, 182) for selectively disabling exhaust gas flow through certain ones of said number of exhaust gas flow paths (162) further includes a third exhaust gas control valve (178, 180, 182) responsive to a third control signal to enable gas flow through a said gas bypass channel (172).

6. Apparatus (125) for controlling the temperature of recirculated exhaust gas in an internal combustion engine (12) according to claim 1, wherein said means (145, 150, 178, 180, 182) for selectively disabling exhaust gas through certain ones of said number of exhaust gas flow paths (142, 162) has a first exhaust gas control valve (150, 178, 180, 182) responsive to a first control signal; and said means (152, 184, 186, 188) for controlling said means (145, 150, 178, 180, 182) for selectively disabling exhaust gas flow through certain ones of said number of exhaust gas flow paths (142, 162) includes means (126) for producing said first control signal to thereby control said recirculated exhaust gas temperature.

7. Apparatus (125) according to claim 6, wherein said first exhaust gas control valve (150, 178, 180, 182) is responsive to said first control signal to disable gas flow through a first subset (146, 166A, 166B, 166C, 168A, 168B, 168C, 170A, 170B) of said number of exhaust gas flow paths (142, 162) to thereby vary said heat exchange capability of said heat exchanger (120).

8. Apparatus (125) according to claim 2 or claim 7, wherein said first subset (146) of said number of exhaust gas flow paths (142) includes approximately one half of said number of exhaust flow paths (162).

9. Apparatus (125) according to claim 7, further including a second exhaust gas control valve (178, 180,182) responsive to a second control signal to disable gas flow through a second subset (166A, 166B, 166C, 168A, 168B, 168C, 170A, 170B) of said number of exhaust gas flow paths (162) to thereby vary said heat exchange capability of said heat exchanger (120); and

wherein said means (126) for producing said first control signal includes means for producing said second control signal.

10. Apparatus (125) according to claim 9, further including a third exhaust gas control valve (178, 180, 182) responsive to a third control signal to disable gas flow through a third subset (166A, 166B, 166C, 168A, 168B, 168C) of said number of exhaust gas flow paths (162) to thereby vary said heat exchange capability of said heat exchanger (120); and

wherein said means (126) for producing said first and second control signals includes means for producing said third control signal.

11. Apparatus (125) according to claim 4 or claim 10, wherein each of said first , second and third subsets (166A, 166B, 166C, 168A, 168B, 168C) of said number of exhaust gas flow paths (162) include approximately an equal number of exhaust gas flow paths (162).

12. Apparatus (125) according to claim 4 or claim 10, wherein said first, second and third subsets (166A, 166B, 166C, 168A, 168B, 168C) of said number of exhaust gas flow paths (162) include unequal number of exhaust gas flow paths (162).

13. Apparatus (125) according to claim 9, wherein said heat exchanger (120) defines a gas bypass channel (172) therethrough from said gas inlet port (122) to said gas outlet port (124), said gas bypass channel (172) bypassing providing for exhaust gas flow therethrough with a minimal effect of the temperature of the exhaust gas;

and further including a third exhaust gas control valve (178, 180, 182) responsive to a third control signal to enable gas flow through a said gas bypass channel (172);

and wherein said means (126) for producing said first and second control signals includes means for producing said third control signal.

14. Apparatus (125) according to claim 5 or claim 9, wherein said first, second and third exhaust gas control valves (178, 180 and 182) are responsive to said first, second and third control signals to direct air flow through desired ones of said first and second subsets (170A and 170B) of said gas flow paths (162) and said gas bypass channel (172) to simultaneously vary said heat exchange capability of said heat exchanger (120) and modulate a flow rate of said recirculated exhaust gas to said air inlet port (122) of the engine (12).

15. Apparatus (125) according to any one of claims 2 to 5, 7, 10, 13 and 14, wherein either said means (152, 184, 186, 188) for controlling said means (145, 150, 178, 180, 182) for selectively disabling exhaust gas flow through certain ones of said number of exhaust gas flow paths (142, 162), or said means (126) for producing either said first control signal or said first, second and third control signals includes means (126 and 90, 94, 98 and 102 or 126 and 29) for determining either recirculated

exhaust gas temperature or a flow rate of said recirculated exhaust gas and producing the respective control signal or control signals in accordance therewith to thereby control the temperature of said recirculated exhaust gas.

16. Apparatus (125) according to claim 11, wherein said means (126 and 90, 94, 98 and 102 or 126 and 29) for determining either recirculated exhaust gas temperature or a flow rate of said recirculated gas includes:

a sensor which is a temperature sensor (90, 94, 98, 102) or a pressure sensor (29) as appropriate disposed within said recirculated exhaust gas, said sensor producing a respective temperature signal or gas pressure signal corresponding to said recirculated exhaust gas temperature or the pressure of said recirculate gas; and
an electronic control system (126) responsive to said temperature or pressure signal to produce either said first control signal or said first, second and third control signals.

17. Apparatus (125) according to claim 12, wherein said sensor (94) is disposed within said gas outlet port (124) of said heat exchanger (120).

18. Apparatus (125) according to claim 11, wherein said heat exchanger (120) includes a housing (140, 160) defining said gas inlet port (122) and said gas outlet port (124), and housing said number of exhaust gas flow paths (142, 162) therein;
and wherein said means (126 and 90, 94, 98 and 102) for determining recirculated exhaust gas temperature includes:

a temperature sensor (98) operable to sense heat exchanger housing temperature and produce a temperature signal corresponding thereto; and
an electronic control system (126) responsive to said temperature signal to produce either said first control signal or said first, second and third control signals.

19. Apparatus according to claim 18, wherein said temperature sensor (98) is attached to an outer surface of said heat exchanger housing (140, 160).

Patentansprüche

1. Vorrichtung (125) zum Steuern der Temperatur von rückgeführtem Abgas in einem Verbrennungsmotor (12), mit
einer ersten Leitung (51 und 52), die an einem Ende an eine Abgasöffnung (18) des Motors (12) gekuppelt ist;
einer zweiten Leitung (32 und 60), die an einem Ende an eine Lufteinlaßöffnung (14) des Motors (12) gekuppelt ist;
einem Wärmetauscher (120), der eine Gaseinlaßöffnung (122), die an ein entgegengesetztes Ende der ersten Leitung (51 und 52) angeschlossen ist und Abgas daraus empfängt, eine Gasauslaßöffnung (124), die an ein entgegengesetztes Ende der zweiten Leitung (32 und 60) angeschlossen ist und rückgeführtes Abgas dorthin liefert, enthält, wobei der Wärmetauscher (120) einen Abgasströmungsweg (142, 162) durch sich hindurch von der Gaseinlaßöffnung (122) zu der Gasauslaßöffnung (124) bildet;
gekennzeichnet dadurch,
daß der Abgasströmungsweg einer von einer Anzahl von solchen Abgasströmungswegen (142, 162) durch den Wärmetauscher (120) von der Gaseinlaßöffnung (122) zu der Gasauslaßöffnung (124) ist;
durch eine Einrichtung (145, 150, 178, 180, 182) zum selektiven Abschalten eines Abgasstromes durch bestimmte der Anzahl von Abgasströmungswegen (142, 162) ;
und durch
eine Einrichtung (152, 184, 186, 188) zum Steuern der Einrichtung (145, 150, 178, 180, 182) zum selektiven Abschalten eines Abgasstromes durch bestimmte der Anzahl von Abgasströmungswegen (142, 162), um dadurch die Temperatur des rückgeführten Abgases zu steuern.

2. Vorrichtung (125) nach Anspruch 1, bei der die Einrichtung (145, 150, 178, 180, 182) zum selektiven Abschalten eines Abgasstromes durch bestimmte der Anzahl von Abgasströmungswegen (142, 162) ein erstes Abgassteuerungsventil (150, 178, 180, 182) enthält, das auf ein erstes Steuersignal ansprechend ist, um einen Gasstrom durch eine erste Untergruppe (146, 166A, 166B, 166C, 168A, 168B, 168C, 170A, 170B) der Anzahl von Abgasströmungswegen (142, 162) abzuschalten, um dadurch das Wärmetauschvermögen des Wärmetauschers (120) zu verändern.

3. Vorrichtung (125) nach Anspruch 2, bei der die Einrichtung (178, 180, 182) zum selektiven Abschalten eines Abgasstromes durch bestimmte der Anzahl von Abgasströmungswegen (162) ein zweites Abgassteuerungsventil (178, 180, 182) enthält, das auf ein zweites Steuersignal ansprechend ist, um einen Gasstrom durch eine zweite Untergruppe (166A, 166B, 166C, 168A, 168B, 168C, 170A, 170B) der Anzahl von Gasströmungswegen (162) abzuschalten, um dadurch das Wärmetauschvermögen des Wärmetauschers (120) zu verändern.

4. Vorrichtung (125) nach Anspruch 3, bei der die Einrichtung (178, 180, 182) zum selektiven Abschalten eines Abgasstromes durch bestimmte der Anzahl von Abgasströmungswegen (162) ein drittes Abgassteuerungsventil (178, 180, 182) enthält, das auf ein drittes Steuersignal ansprechend ist, um einen Gasstrom durch eine dritte Untergruppe (166A, 166B, 166C, 168A, 168B, 168C, 170A, 170B) der Anzahl von Abgasströmungswegen (162) abzuschalten, um dadurch das Wärmetauschvermögen des Wärmetauschers (120) zu verändern.

5. Vorrichtung (125) nach Anspruch 3, bei der der Wärmetauscher (120) einen Gasbypasskanal (172) durch sich hindurch von der Gaseinlaßöffnung (122) zu der Gasauslaßöffnung (124) bildet, wobei der Gasbypasskanal (172) für einen Abgasstrom durch sich hindurch mit einer minimalen Auswirkung auf die Temperatur des Abgases sorgt;
und bei der die Einrichtung (178, 180, 182) zum selektiven Abschalten eines Abgasstromes durch bestimmte der Anzahl von Abgasströmungswegen (162), ferner ein drittes Abgassteuerungsventil (178, 180, 182) enthält, das auf ein drittes Steuersignal ansprechend ist, um einen Gasstrom durch einen besagten Gasbypasskanal (172) zuzulassen.

6. Vorrichtung (125) zum Steuern der Temperatur von rückgeführtem Abgas in einem Verbrennungsmotor (12) nach Anspruch 1, bei der die Einrichtung (145, 150, 178, 180, 182) zum selektiven Abschalten eines Abgasstromes durch bestimmte der Anzahl von Abgasströmungswegen (142, 162) ein erstes Abgassteuerungsventil (150, 178, 180, 182) hat, das auf ein erstes Steuersignal ansprechend ist, und die Einrichtung (152, 184, 186, 188) zum Steuern der Einrichtung (145, 150, 178, 180, 182) zum selektiven Abschalten eines Abgasstromes durch bestimmte der Anzahl von Abgasströmungswegen (142, 162) eine Einrichtung (126) zum Erzeugen des ersten Steuersignals enthält, um dadurch die Temperatur des rückgeführten Abgases zu steuern.

7. Vorrichtung (125) nach Anspruch 6, bei der das erste Abgassteuerungsventil (150, 178, 180, 182) auf das erste Steuersingal ansprechend ist, um einen Gasstrom durch eine erste Untergruppe (146, 166A, 166B, 166C, 168A, 168B, 168C, 170A, 170B) der Anzahl von Abgasströmwegen (142, 162) abzuschalten, um dadurch das Wärmetauschvermögen des Wärmetauschers (120) zu verändern.

8. Vorrichtung (125) nach Anspruch 2 oder Anspruch 7, bei der die erste Untergruppe (146) der Anzahl von Abgasströmungswegen (142) ungefähr die Hälfte der Anzahl von Abgasströmungswegen (162) enthält.

9. Vorrichtung (125) nach Anspruch 7, ferner mit einem zweiten Abgassteuerungsventil (178, 180, 182), das auf ein zweites Steuersignal ansprechend ist, um einen Gasstrom durch eine zweite Untergruppe (166A, 166B, 166C, 168A, 168B, 168C, 170A, 170B) der Anzahl von Abgasströmungswegen (162) abzuschalten, um dadurch das Wärmetauschvermögen des Wärmetauschers (120) zu verändern; und
bei der die Einrichtung (126) zum Erzeugen des ersten Steuersignals eine Einrichtung zum Erzeugen des zweiten Steuersignals enthält.

10. Vorrichtung (125) nach Anspruch 9, ferner mit einem dritten Abgassteuerungsventil (178, 180, 182), das auf ein drittes Steuersignal ansprechend ist, um einen Gasstrom durch eine dritte Untergruppe (166A, 166B, 166C, 168A, 168B, 168C) der Anzahl von Abgasströmungswegen (162) abzuschalten, um dadurch das Wärmetauschvermögen des Wärmetauschers (120) zu verändern; und
bei der die Einrichtung (126) zum Erzeugen des ersten und zweiten Steuersignals eine Einrichtung zum Erzeugen des dritten Steuersignals enthält.

11. Vorrichtung (125) nach Anspruch 4 oder Anspruch 10, bei der jede der ersten, zweiten und dritten Untergruppe (166A, 166B, 166C, 168A, 168B, 168C) der Anzahl von Abgasströmungswegen (162) ungefähr die gleiche Anzahl von Abgasströmungswegen (162) enthält.

12. Vorrichtung (125) nach Anspruch 4 oder Anspruch 10, bei der die erste, zweite und dritte Untergruppe (166A, 166B, 166C, 168A, 168B, 168C) der Anzahl von Abgasströmungswegen (162) eine ungleiche Anzahl von Abgasströmungswegen (162) enthält.

13. Vorrichtung (125) nach Anspruch 9, bei der der Wärmetauscher (120) einen Gasbypasskanal (172) durch sich hindurch von der Gaseinlaßöffnung (122) zu der Gasauslaßöffnung (124) bildet, wobei der Gasbypasskanal (172) durch die Umgehung für einen Abgasstrom durch sich hindurch mit einer minimalen Auswirkung auf die Temperatur des Abgases sorgt;
und ferner mit einem dritten Abgassteuerungsventil (178, 180, 182), das auf ein drittes Steuersignal ansprechend ist, um einen Gasstrom durch einen besagten Gasbypasskanal (172) zuzulassen;
und bei der die Einrichtung (126) zum Erzeugen des ersten und zweiten Steuersignals eine Einrichtung zum Erzeugen des dritten Steuersignals enthält.

14. Vorrichtung (125) nach Anspruch 5 oder Anspruch 9, bei der das erste, zweite und dritte Abgassteuerungsventil (178, 180 und 182) auf das erste, zweite und dritte Steuersignal ansprechend sind, um einen

Luftstrom durch eine gewünschte, der ersten und zweiten Untergruppe (170A und 170B) der Gasströmungswege (162) und des Gasbypasskanals (172) zu lenken, um gleichzeitig das Wärmetauschvermögen des Wärmetauschers (120) zu verändern und eine Strömungsgeschwindigkeit des rückgeführten Abgases zu der Lufteinlaßöffnung (122) des Motors (12) zu modulieren.

15. Vorrichtung (125) nach irgendeinem der Ansprüche 2 bis 5, 7, 10, 13 und 14), bei der entweder die Einrichtung (152, 184, 186, 188) zum Steuern der Einrichtung (145, 150, 178, 180, 182) zum selektiven Abschalten eines Abgasstromes durch bestimmte, der Anzahl von Abgasströmungswegen (142, 162), oder die Einrichtung (126) zum Erzeugen entweder des ersten Steuersignals oder des ersten, zweiten und dritten Steuersignals eine Einrichtung (126 und 90, 94, 98 und 102 oder 126 und 29) zum Bestimmen entweder der Temperatur des rückgeführten Abgases oder der Strömungsgeschwindigkeit des rückgeführten Abgases und Erzeugen des jeweiligen Steuersignals oder der Steuersignale in Einklang damit enthält, und dadurch die Temperatur des rückgeführten Abgases zu steuern.

16. Vorrichtung (125) nach Anspruch 11, bei der die Einrichtung (126 und 90, 94, 98 und 102 oder 126 und 29) zum Bestimmen entweder der Temperatur des rückgeführten Abgases oder der Strömungsgeschwindigkeit des rückgeführten Gases enthält, einen Sensor, der ein Temperatursensor (90, 94, 98, 102) oder ein Drucksensor (29), je nach Zweckmäßigkeit, ist der in dem rückgeführten Abgas angeordnet ist, wobei der Sensor ein jeweiliges Temperatursignal oder ein Gasdrucksignal erzeugt, das der Temperatur des rückgeführten Abgases oder dem Druck des rückgeführten Gases entspricht; und
ein elektronisches Steuerungssystem (126), das auf das Temperatur- oder Drucksignal ansprechend ist, um entweder das erste Steuersignal oder das erste, zweite und dritte Steuersignal zu erzeugen.

17. Vorrichtung (125) nach Anspruch 12, bei der der Sensor (94) in der Gasauslaßöffnung (124) des Wärmetauschers (120) angeordnet ist.

18. Vorrichtung (125) nach Anspruch 11, bei der der Wärmetauscher (120) ein Gehäuse (140, 160) enthält, das die Gaseinlaßöffnung (122) und die Gasauslaßöffnung (124) bildet und die Anzahl von Abgasströmungswegen (142, 162) unterbringt;
und bei der die Einrichtung (126 und 90, 94, 98 und 102) zum Bestimmen der Temperatur des rückgeführten Abgases enthält,
einen Temperatursensor (98), der betriebsbereit ist, um die Temperatur des Wärmetauschergehäuses zu fühlen und ein dem entsprechendes Temperatursignal zu erzeugen; und
ein elektronisches Steuersystem (126), das auf das Temperatursignal ansprechend ist, um entweder das erste Steuersignal oder das erste, zweite und dritte Steuersignal zu erzeugen.

19. Vorrichtung nach Anspruch 18, bei der der Temperaturfühler (98) an einer äußeren Fläche des Wärmetauschergehäuses (140, 160) befestigt ist.

Revendications

1. Appareil (125) pour réguler la température des gaz d'échappement recyclés d'un moteur à combustion interne (12), comprenant :

un premier conduit (51 et 52) couplé par une extrémité à un orifice (18) des gaz d'échappement du moteur (12) ;
un second conduit (32 et 60) couplé par une extrémité à un orifice (14) d'entrée d'air du moteur (12) ;
un échangeur de chaleur (120) comprenant un orifice (122) d'entrée des gaz relié à une extrémité opposée dudit premier conduit (51 et 52) et recevant les gaz d'échappement à partir de celui-ci, un orifice (124) de sortie des gaz relié à une extrémité opposée dudit second conduit (32 et 60) et fournissant à celui-ci des gaz d'échappement recyclés, ledit échangeur de chaleur (120) définissant à travers lui un trajet d'écoulement (142, 162) des gaz d'échappement depuis ledit orifice (122) d'entrée des gaz jusqu'audit orifice (124) de sortie des gaz ;

caractérisé par le fait que
ledit trajet d'écoulement des gaz d'échappement est l'un de nombreux tels trajets d'écoulement (142, 162) des gaz d'échappement à travers ledit échangeur de chaleur (120) depuis ledit orifice (122) d'entrée des gaz jusqu'audit orifice (124) de sortie des gaz ;
des moyens (145, 150, 178, 180, 182) pour empêcher de manière sélective l'écoulement des gaz d'échappement à travers certains desdits nombreux trajets d'écoulement (142, 162) des gaz d'échappement ; et
des moyens (152, 184, 186, 188) pour commander lesdits moyens (145, 150, 178, 180, 182) pour empêcher de manière sélective l'écoulement des gaz d'échappement à travers certains desdits nombreux trajets d'écoulement (142, 162) des gaz d'échappement de manière ainsi à réguler la température desdits gaz d'échappement recyclés.

2. Appareil (125) selon la revendication 1, dans lequel

lesdits moyens (145, 150, 178, 180, 182) pour empêcher de manière sélective l'écoulement des gaz d'échappement à travers certains desdits nombreux trajets d'écoulement (142, 162) des gaz d'échappement comprennent une première vanne de régulation des gaz d'échappement (150, 178, 180, 182) sensible à un premier signal de commande pour empêcher l'écoulement des gaz à travers un premier sous-ensemble (146, 166A, 166B, 166C, 168A, 168B, 168C, 170A, 170B) desdits nombreux trajets d'écoulement (142, 162) des gaz d'échappement de manière ainsi à faire varier ladite capacité d'échange thermique dudit échangeur de chaleur (120).

3. Appareil (125) selon la revendication 2, dans lequel lesdits moyens (178, 180, 182) pour empêcher de manière sélective l'écoulement des gaz d'échappement à travers certains desdits nombreux trajets d'écoulement (162) des gaz d'échappement comprennent une seconde vanne de régulation des gaz d'échappement (178, 180, 182) sensible à un second signal de commande pour empêcher l'écoulement des gaz à travers un second sous-ensemble (166A, 166B, 166C, 168A, 168B, 168C, 170A, 170B) desdits nombreux trajets d'écoulement (162) des gaz d'échappement de manière ainsi à faire varier ladite capacité d'échange thermique dudit échangeur de chaleur (120).

4. Appareil (125) selon la revendication 3, dans lequel lesdits moyens (178, 180, 182) pour empêcher de manière sélective l'écoulement des gaz d'échappement à travers certains desdits nombreux trajets d'écoulement (162) des gaz d'échappement comprennent une troisième vanne de régulation des gaz d'échappement (178, 180, 182) sensible à un troisième signal de commande pour empêcher l'écoulement des gaz à travers un troisième sous-ensemble (166A, 166B, 166C, 168A, 168B, 168C, 170A, 170B) desdits nombreux trajets d'écoulement (162) des gaz d'échappement de manière ainsi à faire varier ladite capacité d'échange thermique dudit échangeur de chaleur (120).

5. Appareil (125) selon la revendication 3, dans lequel ledit échangeur de chaleur (120) définit un canal de dérivation des gaz (172) à travers lui depuis ledit orifice (122) d'entrée des gaz jusqu'audit orifice (124) de sortie des gaz, ledit canal de dérivation des gaz (172) permettant un écoulement des gaz d'échappement à travers lui avec un effet minimal sur la température des gaz d'échappement ;

et dans lequel lesdits moyens (178, 180, 182) pour empêcher de manière sélective d'écoulement des gaz d'échappement à travers certains desdits nombreux trajets d'écoulement (162) des gaz d'échappement comprennent en outre une troisième vanne de régulation des gaz d'échappement (178, 180, 182) sensible à un troisième signal de commande pour permettre l'écoulement des gaz à travers ledit canal de dérivation des gaz (172).

6. Appareil (125) pour réguler la température des gaz d'échappement recyclés d'un moteur à combustion interne (12) selon la revendication 1, dans lequel lesdits moyens (145, 150, 178, 180, 182) pour empêcher de manière sélective l'écoulement des gaz d'échappement à travers certains desdits nombreux trajets d'écoulement (142, 162) des gaz d'échappement comprennent une première vanne de régulation des gaz d'échappement (150, 178, 180, 182) sensible à un premier signal de commande ; et lesdits moyens (152, 184, 186, 188) pour commander lesdits moyens (145, 150, 178, 180, 182) pour empêcher de manière sélective l'écoulement des gaz d'échappement à travers certains desdits nombreux trajets d'écoulement (142, 162) des gaz d'échappement comprennent des moyens (126) pour produire ledit premier signal de commande de manière ainsi à réguler ladite température des gaz d'échappement recyclés.

7. Appareil (125) selon la revendication 6, dans lequel ladite première vanne de régulation des gaz d'échappement (150, 178, 180, 182) est sensible audit premier signal de commande pour empêcher l'écoulement des gaz à travers un premier sous-ensemble (146, 166A, 166B, 166C, 168A, 168B, 168C, 170A, 170B) desdits nombreux trajets d'écoulement (142, 162) des gaz d'échappement de manière ainsi à faire varier ladite capacité d'échange thermique dudit échangeur de chaleur (120).

8. Appareil (125) selon la revendication 2 ou la revendication 7, dans lequel ledit premier sous-ensemble (146) desdits nombreux trajets d'écoulement (142) des gaz d'échappement comprend approximativement une moitié desdits nombreux trajets d'écoulement d'échappement (162).

9. Appareil (125) selon la revendication 7, comprenant en outre une seconde vanne de régulation des gaz d'échappement (178, 180, 182) sensible à un second signal de commande pour empêcher l'écoulement des gaz à travers un second sous-ensemble (166A, 166B, 166C, 168A, 168B, 168C, 170A, 170B) desdits nombreux trajets d'écoulement (162) des gaz d'échappement de manière ainsi à faire varier ladite capacité d'échange thermique dudit échangeur de chaleur (120) ; et

dans lequel lesdits moyens (126) pour produire ledit premier signal de commande comprennent des moyens pour produire ledit second signal de commande.

10. Appareil (125) selon la revendication 9, comprenant en outre une troisième vanne de régulation des gaz d'échappement (178, 180, 182) sensible à un troisième signal de commande pour empêcher l'écoulement des gaz à travers un troisième sous-ensemble (166A, 166B, 166C, 168A, 168B, 168C) desdits nombreux trajets d'écoulement des gaz d'échappement (162) de manière ainsi à faire varier ladite capacité d'échange thermique dudit échangeur de chaleur (120) ; et

dans lequel lesdits moyens (126) pour produire lesdits premier et second signaux de commande comprennent des moyens pour produire ledit troisième signal de commande.

11. Appareil (125) selon la revendication 4 ou la revendication 10, dans lequel chacun desdits premier, second et troisième sous-ensembles (166A, 166B, 166C, 168A, 168B, 168C) desdits nombreux trajets d'écoulement (162) des gaz d'échappement comprennent approximativement un nombre égal de trajets d'écoulement des gaz d'échappement (162).

12. Appareil (125) selon la revendication 4 ou la revendication 10, dans lequel lesdits premier, second et troisième sous-ensembles (166A, 166B, 166C, 168A, 168B, 168C) desdits nombreux trajets d'écoulement (162) des gaz d'échappement comprennent un nombre inégal de trajets d'écoulement des gaz d'échappement (162).

13. Appareil (125) selon la revendication 9, dans lequel ledit échangeur de chaleur (120) définit un canal de dérivation des gaz (172) à travers lui depuis ledit orifice (122) d'entrée des gaz jusqu'audit orifice (124) de sortie des gaz, ladite dérivation du canal de dérivation des gaz (172) permettant un écoulement des gaz d'échappement à travers lui avec un effet minimal de la température des gaz d'échappement ;

et comprenant en outre une troisième vanne de régulation des gaz d'échappement (178, 180, 182) sensible à un troisième signal de commande pour permettre l'écoulement des gaz à travers ledit canal de dérivation des gaz (172) ;

et dans lequel lesdits moyens (126) pour produire lesdits premier et second signaux de commande comprennent des moyens pour produire ledit troisième signal de commande.

14. Appareil (125) selon la revendication 5 ou la revendication 9, dans lequel lesdites première, seconde et troisième vannes de régulation des gaz d'échappement (178, 180 et 182) sont sensibles audits premier, second et troisième signaux de commande pour diriger l'écoulement de l'air à travers des sous-ensembles désirés parmi lesdits premier et second sous-ensembles (170A et 170B) desdits trajets d'écoulement des gaz (162) et dudit canal de dérivation des gaz (172) de manière à faire simultanément varier ladite capacité d'échange thermique du dudit échangeur de chaleur (120) et moduler un taux d'écoulement desdits gaz d'échappement recyclés vers ledit orifice (122) d'entrée d'air du moteur (12).

15. Appareil (125) selon une quelconque des revendications 2 à 5, 7, 10, 13 et 14, dans lequel soit lesdits moyens (152, 184, 186, 188) pour commander lesdits moyens (145, 150, 178, 180, 182) pour empêcher de manière sélective l'écoulement des gaz d'échappement à travers certains desdits nombreux trajets d'écoulement (142, 162) des gaz d'échappement, soit lesdits moyens (126) pour produire soit ledit premier signal de commande soit lesdits premiers second et troisième signaux de commande, comprennent des moyens (126 et 90, 94, 98 et 102 ou 126 et 29) pour déterminer soit la température des gaz d'échappement recyclés soit un taux d'écoulement desdits gaz d'échappement recyclés, et produire le signal de commande ou les signaux de commande respectifs, conformément à cela, de manière ainsi à réguler la température desdits gaz d'échappement recyclés.

16. Appareil (125) selon la revendication 11, dans lequel lesdites moyens (126 et 90, 94, 98 et 102 ou 126 et 29) pour déterminer soit la température des gaz d'échappement recyclés soit un taux d'écoulement desdits gaz recyclés comprennent :

un capteur qui est un capteur de température (90, 94, 98, 102) ou un capteur de pression (29), selon les besoins, disposé à l'intérieur desdits gaz d'échappement recyclés, ledit capteur produisant un signal de température ou un signal de pression des gaz respectif correspondant à ladite température des gaz d'échappement recyclés ou à la pression desdits gaz recyclés ; et

un système électronique de commande (126) sensible audit signal de température ou de pression pour produire soit ledit premier signal de commande, soit lesdits premier, second et troisième signaux de commande.

17. Appareil (125) selon la revendication 12, dans lequel ledit capteur (94) est disposé à l'intérieur dudit orifice (124) de sortie des gaz dudit échangeur de chaleur (120).

18. Appareil (125) selon la revendication 11, dans lequel ledit échangeur de chaleur 120 comprend un boîtier (140, 160) définissant ledit orifice (122) d'entrée des gaz et ledit orifice (124) de sortie des gaz, et logeant à l'intérieur lesdits nombreux trajets

d'écoulement (142, 162) des gaz d'échappement ;
et dans lequel lesdits moyens (126 et 90, 94, 98 et 102) pour déterminer la température des gaz d'échappement recyclés comprennent :

un capteur de température (98) actionnable pour détecter la température du boîtier de l'échangeur de chaleur et produire un signal de température correspondant à celle-ci ; et
un système électronique de commande (126) sensible audit signal de température pour produire soit ledit premier signal de commande, soit lesdits premier, second et troisième signaux de commande.

19. Appareil selon la revendication 18, dans lequel ledit capteur de température (98) est fixé sur une surface externe dudit boîtier (140, 160) de l'échangeur de chaleur.

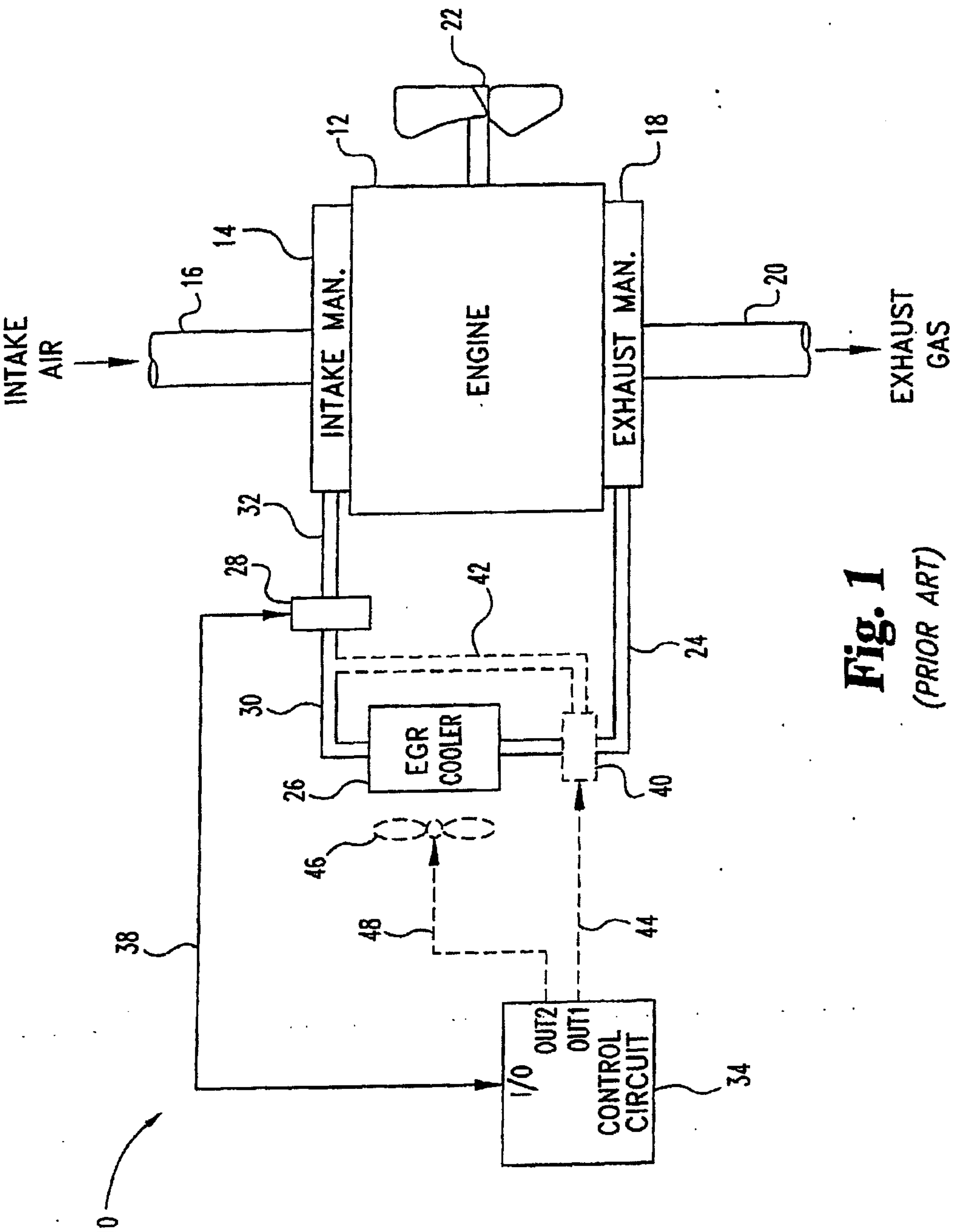

Fig. 1
(PRIOR ART)

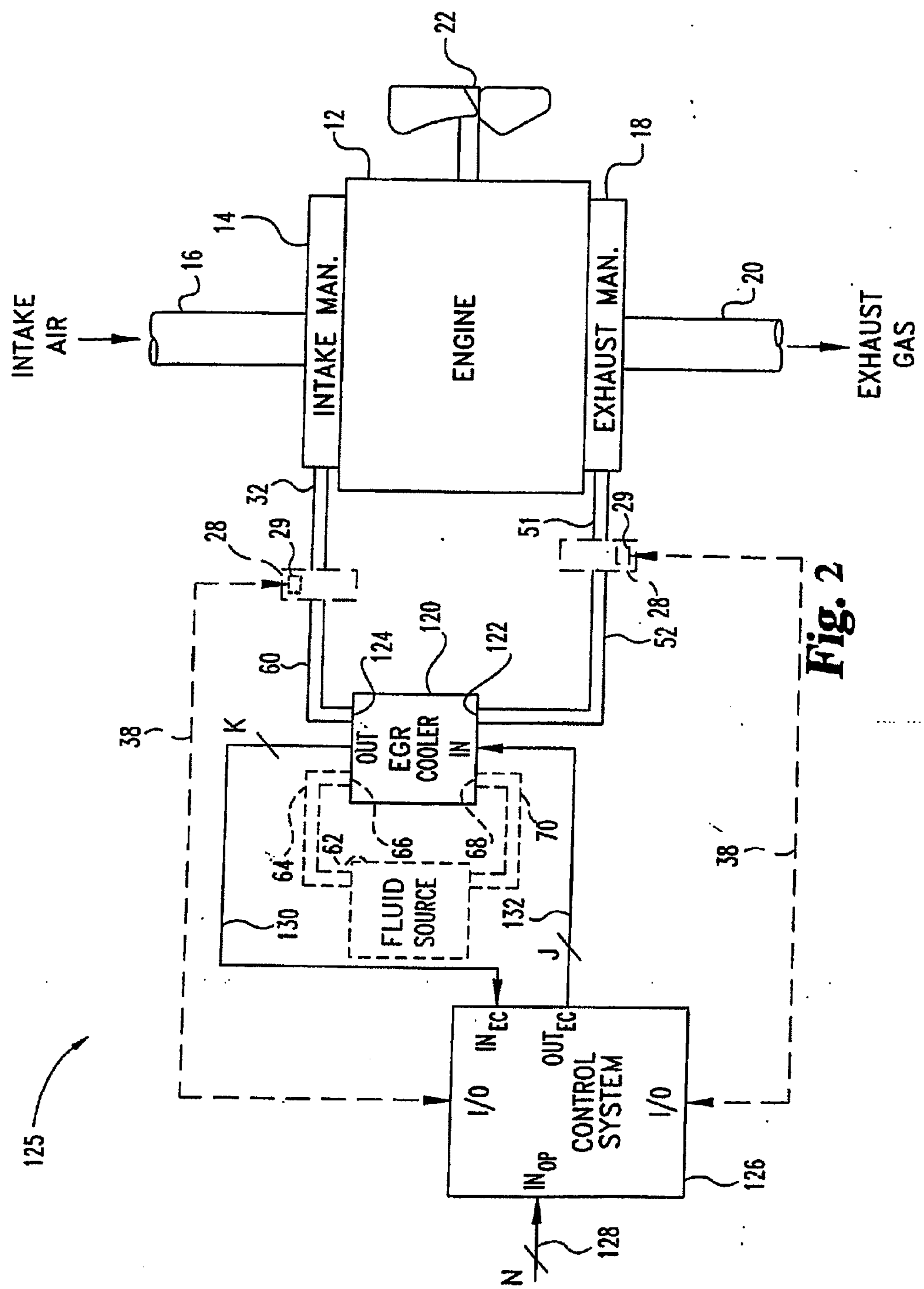
INTAKE AIR
EXHAUST GAS
INTAKE MAN.
ENGINE
EXHAUST MAN.
OUT
EGR COOLER
IN
FLUID SOURCE
IN_EC
OUT_EC
I/O
CONTROL SYSTEM
I/O
IN_OP
K
J
N
12
14
16
18
20
22
28
29
32
51
52
60
62
64
66
68
70
38
120
122
124
125
126
128
130
132

Fig. 2

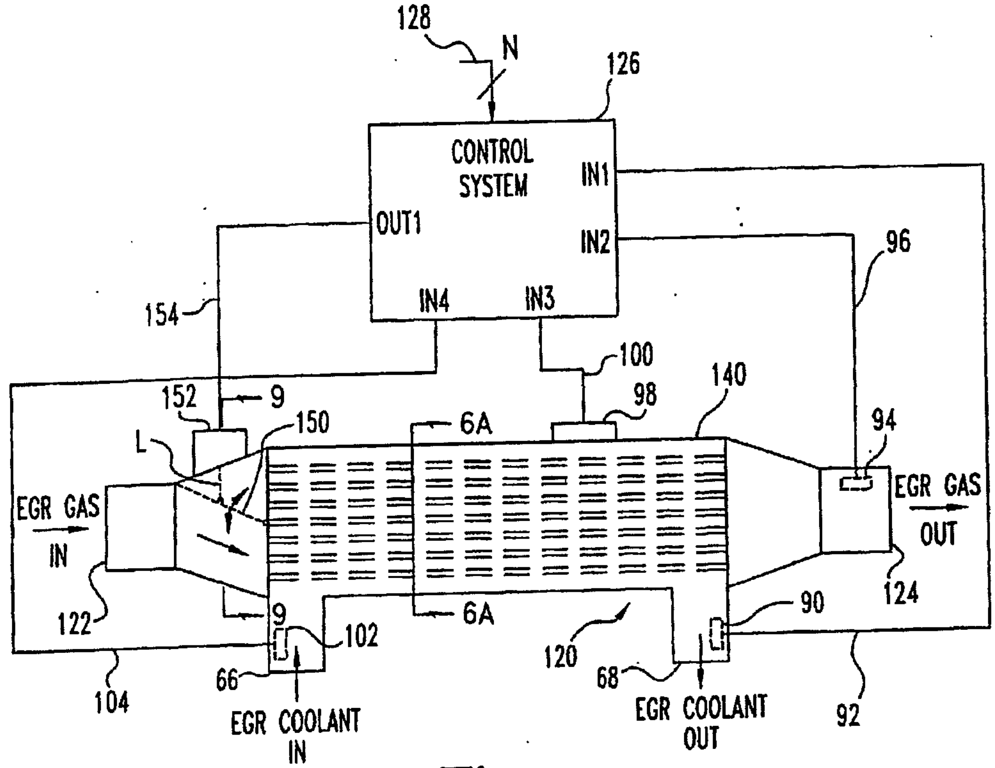
128
N
126
CONTROL SYSTEM
IN1
OUT1
IN2
96
154
IN4
IN3
100
140
152
9
98
L
150
6A
94
EGR GAS IN
EGR GAS OUT
122
9
6A
90
124
102
120
104
66
68
92
EGR COOLANT IN
EGR COOLANT OUT

Fig. 3

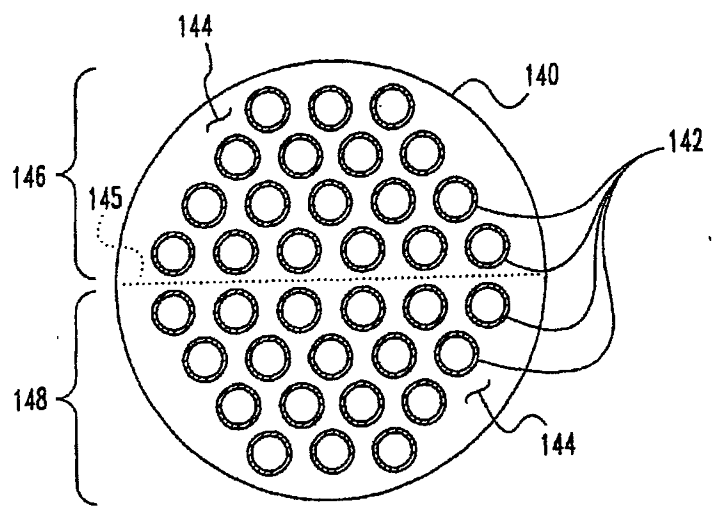
144
140
142
146
145
148
144

Fig. 3A

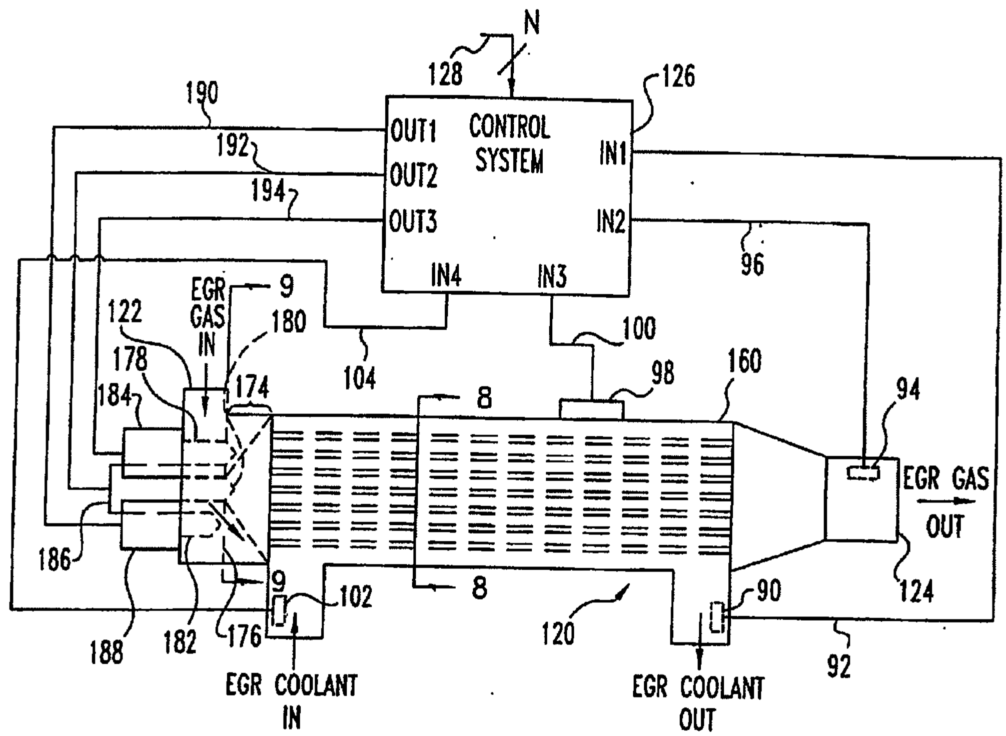

Fig. 4

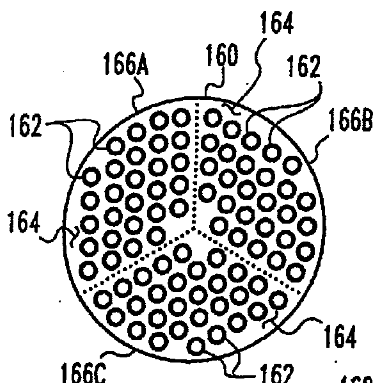

Fig. 5A

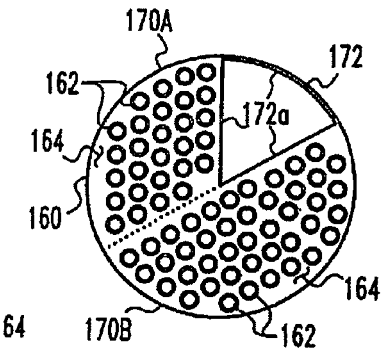

Fig. 5C

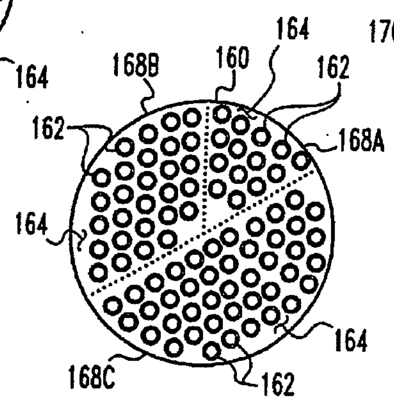

Fig. 5B

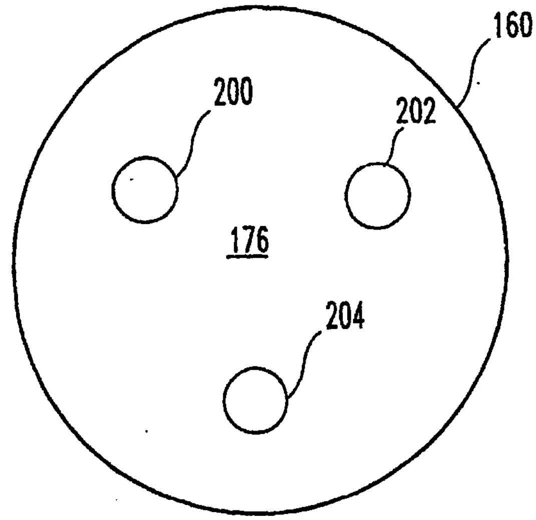

Fig. 6A

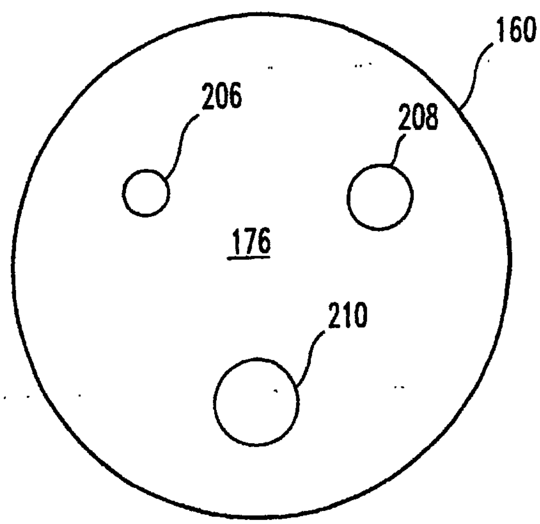

Fig. 6B